The pulvilli are situated between the claws. They are large and glandular, and by secreting a viscid adhesive material enable a bee to walk up a smooth surface like that of glass. We thus understand why a bee fails in its attempt to walk up a moistened or powdered glass surface. When a bee walks on wood the pulvilli are turned back, when on glass the claws are similarly made to change their position.

DIRECTIVE COLORATION IN ANIMALS.

BY J. E. TODD.

MUCH has been written by Wallace, Darwin and others concerning the protective effects of coloration in animals, and this adaptation perhaps accounts for most of the chromatic characteristics of animals. Darwin has also shown how many may be accounted for by sexual selection, and Wallace has referred many of those, still remaining unexplained, to the play of color-producing forces uncontrolled by natural selection.

So far as the author is aware, however, there has been no distinct enunciation of the principle sketched in the following pages. The nearest approach to it is a remark of Darwin in regard to the rabbit's white tail—that it might serve as guide to the young in following the old ones to the burrow; and another—that the stripes of the zebra may be of use to stragglers in recognizing their fellows at a distance. (Vide AM. NAT., 1877.)

Wallace approves the suggestion, and, from some notes of his recent Baltimore lectures, it may be inferred that he has carried the principle further. But in their published writings both these eminent naturalists refer several distinct cases to other sources, which in the following pages will be claimed as examples of what, for want of a better name, we have styled *directive coloration.* And whether the views hereinafter to be advanced prove to be entirely novel or not, they have, so far as here expressed, sprung entirely from the author's own observation and study. He regrets that both have necessarily been so limited that he cannot multiply examples as freely as nature has supplied them. What is here offered is only a sketch of what might be wrought out by any one having time to carry out the work in its details.

The first observations which eventually proved the germ of this paper were made on the plains of Dakota. During the long, monotonous rides over that region, one pleasant circumstance was the sudden rise of various birds from the nearly naked ground and their as sudden disappearance on lighting. Ere long it was noticed that in the process of lighting there was, very commonly, a conspicuous flashing-out of white on wings or tail, or on both. This was noticed in several of the sparrows, the meadow-lark, the lark-bunting, the Carolina dove, and less prominently in the prairie-hen or grouse. Somewhat similar facts were noted also of the jack-rabbit and antelope. The question then arose, very naturally, Why is this prevalent character? Of what advantage is it? For the smaller birds, the answer came readily. The plains are constantly scoured by hovering hawks —therefore, protective coloration is of prime importance. If, however, they should become of a uniform gray color all over, they would be as completely and constantly hidden from their friends as from their foes. That would be quite disastrous, especially where the former are fewer than the latter. To prevent such a result, there is the following arrangement. When at rest, or about the ordinary occupation of feeding, the gray surface only is exposed; the same is true also in some cases during flight; but in checking its velocity for lighting the tail is fully spread, exhibiting the conspicuous colors fully, and marks the location of the leader, that the rest may govern themselves accordingly. To escape the hawk, should he happen to note the location, the sparrow resorts to doubling on its course and skulking. When the danger has passed, the flock, if they have followed the leader, are likely to be within call of one another, and if they have become too much scattered, this same automatic telegraphy must assist much in enabling the stragglers to find their fellows. Some species, as the meadow-lark, have a habit of spreading the tail at almost every chirp. This would seem to work as rationally as the rallying-call of the bugle and the waving of a flag to call a troop together. Yet after all, in the bird it is doubtless mainly automatic, the effort of the cry producing the twitch of the tail, as truly as in the prairie-dog.

But this conspicuous flash tells more than the place of alighting. It reveals the species at hand. These white patches form a kind of natural heraldry among the denizens of the plains, by which each kind is recognized by friend and foe. Its vivid white secures

its utmost efficiency. It is, no doubt, often useful also at night, whenever there is any disturbance by storm or prowling enemy. Thus far, we have had in mind only the ordinary gray birds and animals of the plains, upon which the directive coloration is almost invariably white. But the principle extends farther. When the general coloration is white or light, the directive color is black or dark, as in the pelican, white crane, weasel, etc. In some which may be gray in summer and white in winter, both white and black may be found in close juxtaposition. In a very few, black seems to serve the purpose, even with gray plumage, as in the horned lark and some sparrows (?). The principle may include also cases where more brilliant tints than those of the white-black series are employed.

Soon after our interest had been awakened in the cases already mentioned it was our privilege to examine a large collection of skunks which some fortunate trappers had captured. The striking white lines on the black ground and their fantastic and very variable forms raised again the question, *Why?* Our idea of directive coloration found a new direction for its application, and it readily suggested satisfactory answers to the query. Here were animals living constantly in dusk and darkness. The conspicuous tail, as Belt remarked long ago, may be classed as a warning signal, and therefore protective; but why the elaborate white lines and spots? These are only useful at shorter distances, and, therefore, presumably to fellow-individuals of the same species. We can readily understand how they may clearly reveal not only the general position of the body, but also its attitude; and by the individual variations in the breadth and continuity of the lines, individuals may recognize one another at night, or in their burrows. In short, these directive markings are in this case what signal-lights or flags are to vessels and cars, Similar reasoning accounts for the markings prevalent in the raccoon. badger, chip-munk, and other burrowing animals. So, too, it accounts for some of the markings about the heads of the sparrows, larks, ducks, and numerous other birds; also, about the muzzle, ears and throat of antelope, deer, hares and other mammals, whether protectively colored or not. These markings are more distinct and more frequent about the head, because of its greater expressiveness and importance. Of course, in this general outlining of our idea we need not attempt to classify rigidly particular markings, for some

may be useful in more than one way. For example, the ears of the jack-rabbit may serve to notify his fellow of his presence at a distance, and when close at hand they, doubtless, are very expressive of the bodily position and mental condition of their owner.

Looking now over the whole animal kingdom, so far as the more comprehensive works on natural history and more careful descriptions of our local faunas will allow us, we find a vast number of spots and lines about the head, shoulders, flanks and tails of animals belonging to all the so-called sub-kingdoms; and we find in our theory a plausible explanation, in harmony with the workings of natural selection.

We find some, however, which, while properly associated with the cases already described, do not come under either of them exactly. Hitherto we have considered where only a few individuals were concerned and only in the casual relations of ordinary life. There are cases where large numbers herd together, oftentimes moving rapidly in crowded phalanx or disorderly mass, where each must closely regulate his movements according to the action of his immediate companions if he would avoid collision and injury. Not only is this important in diurnal travels, but in the nocturnal bivouac, and especially in a stampede at night. In this way we may explain the stripes of the zebra, koodo, etc., and the numerous bright and extended markings on the various African antelopes. It would seem that the greater and more ferocious carnivores of the tropics might have an influence to intensify these features. The bright markings of hyenas and the hunting-dogs are other conspicuous examples, traceable to quite a different combination of circumstances. Less striking marks, which we have noted under another head, may be also helpful in the way just described. For instance, the markings about the head and tail of wild geese and ducks and the black tips of the wings of pelicans may assist them much in keeping their regular order of flight; so, also, the markings upon sparrows, which are helpful in the ways already indicated, during their summer-life may also be of service during their migrations by helping them to harmonize their movements.

It will be seen by a moment's thought that most of the markings helping to show the position of the body may be of pre-eminent value during courtship, especially during the supreme moments of coition. It would not be strange if this advantage might have a tendency

to intensify certain lateral and caudal markings, or even to produce in them sexual differences. We should naturally expect this to be as manifest in nocturnal animals as anywhere. To this cause we are disposed to refer the different colors of the wing-spots of night-hawks and other Caprimulgidæ: In the males they are white, while in the females they are rufous. Possibly, some of the cases which Darwin considers the results of sexual selection transferred from the male to the female may be referred to this influence.

Another relation may, presumably, modify directive coloration to a considerable degree, especially in animals which, though roving the fields themselves, secrete their young. Deer, swine, lions, etc., may be taken as examples of this. The vivid markings upon the young may assist much in the care which the mother gives in the dim light of the hiding-place and at night. This explanation does not necessarily conflict with the more commonly received opinion —that they are the effect of heredity, revealing the coloration of some remote ancestor. It suggests, rather, the further inference that that ancestor was either gregarious and living on open plains, or else was more solitary and prowling, skulking in dim lights. Our theory would offer a rational explanation for its persistence in the earlier stages of living species.

It will be noticed that we have drawn our illustrations entirely from the mammals and birds. We would not imply that our theory is limited to these. Insects, fishes and reptiles may afford equally good examples.

We would remark, in conclusion, that this sketch does not attempt to give details more than may be necessary to present our view intelligibly. Of course, we recognize the validity of the theory of typical coloration consisting of those primal tints and patterns which have been ascribed to the combined action of chemical, physical and vital forces only; also the theories of protective and ornamental colorations, which have been evolved from the typical by the action of natural and sexual selection. We do not profess to be able to refer every tint and pattern of coloration to its predetermining condition or advantage. That would be well-nigh impossible. But if enough has been given and with sufficient discrimination to satisfy most minds, that adaptation for directive purpose is a real advantage which has been decidedly effective in determining the coloration of animals we are content.

A Synopsis of Directive Coloration in Animals.

Directive coloration is that which is in any way useful to a species by assisting in mutual recognition between individuals, or by indicating, one to another, their attitude of body and probable movements.

1. Marks and tints, promoting recognition at a distance, to guide in straggling flight and to bring stragglers together. [A.]

2. Those indicating the attitude of the body and its probable movement [B] in darkness of night, or in dens; [C] in close movements of large numbers, by day as well as by night; [D] in intercourse of the sexes; [E] in the care of young.

A. [a] By having the general color more or less strikingly contrasted with the environment.—Crows, buzzards, blue-birds, woodpeckers, etc.

[b] When general color is inconspicuous: by having striking colors upon parts of the body which may be hidden during rest, but capable of display automatically either during flight, at the moment of stopping, or during a calling cry, viz.:

Conspicuous colors about the tail:—[Mammals] Rabbit, deer, prong-horn, many antelope, Rocky Mountain sheep, chamois, etc., etc. Outer tail-feathers conspicuous:—[Birds] Snow-bird, meadow-lark, many finches, robin and many thrushes, most warblers, many vireos, night-hawk, ptarmigan, horned-lark, etc. A terminal band: Turkey, king-bird, and many fly-catchers, turtle-dove and other pigeons, grouse, etc. Under-coverts: Prairie-hen, coot, galinule, many snipe, many ducks and geese, etc. Rump and upper coverts: Hawks, flickers, and other Picariæ, most geese, etc.

Conspicuous colors about lateral appendages:—In Mammals, the ears (more frequently on the back side)—hares, deer, etc.; in Birds, the wings—many finches, coots, upland-plover, pelican, snow-goose, crane, many warblers, vireos, etc.

B. [a] By striking marks about the head and neck:—[Mammals] Raccoon, badger, skunk, coatis, many antelope and rodentia, etc. [Birds] Many raptores, sparrows, fly-catchers, warblers, anseres, etc., etc.

[b] By various spots and lines on shoulders or sides:—Skunks, chip-munks, antelope, peccaries, chevrotains, etc.

[c] By paleness of belly and inner side of legs:—Cases too numerous to name.

C. [a] Not only by many of the markings already described, but especially by more vivid and extensive marks upon the shoulders, sides and flanks:—Zebra, wild asses, antelope, giraffe, hunting-dogs, etc.

[b] By special marking of the legs and feet upon the outside:—Zebra, antelope, etc.

D. [a] By most of the lateral and caudal markings already mentioned.

[b] By different colors, according to sex:—Night-hawks and other Caprimulgidæ.

[c] By difference in extent or shape of markings, according to sex:—Antelope, etc.

E. By various spots and lines, appearing only in the younger stages:—Deer, some swine, some Felidæ, etc.

SYNOPSIS OF ROSENBUSCH'S NEW SCHEME FOR THE CLASSIFICATION OF MASSIVE ROCKS.

BY W. S. BAYLEY.

ACCORDING to the new scheme for the classification of massive rocks, proposed by Professor H. Rosenbusch of Heidelberg in the second edition of his "Mikroskopische Physiographie der Massigen Gesteine," these are divided into three great groups, (I) intrusive rocks, (II) vein rocks, and (III) effusive rocks. The fundamental notion underlying this classification is briefly as follows: the structure possessed by rock masses as we find them in the earth is dependent upon two circumstances—(1) the chemical composition of their original liquid magmas, and (2) the conditions under which these magmas cooled. The effect of chemical composition upon the structure assumed by a rock magma in its passage to a solid state has not been definitely ascertained. Results recently obtained by Lagorio, however, indicate that the composition of the unsolidified portions of rock masses, exerts much more influence upon the final structure of the rock than has hitherto been supposed. The rapidity with which a rock cooled, as well as the conditions under which this took place, have long been known to be quite influential in determining its structure. Those rocks which cooled